541933

Final Technical Report

for

Development of Advanced Casing Treatments for Flow Control

NASA Grant Number
NAG3-2507

Grant Duration
October 1, 2000 to July 17, 2001

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August 2001

Development of Advanced Casing Treatments for Flow Control

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Under the Base R&T and Ultra Efficient Engine Technology programs, the NASA-GRC Compressor Branch is investigating flow control strategies required to increase the loading and efficiency of core compressors while maintaining current levels of operability. Flow-control strategies being studied include advanced casing treatments, wall jet injection, and blade-tip injection for compressor stability enhancement, directed jets for surface boundary layer control, and vortex-generating devices. The use of CFD simulations to assess the effectiveness of flow-control devices and to guide their design is a key element in this research. CFD simulations serve to screen potential flow-control concepts at a lower cost than executing physical experiments in turbomachinery facilities. CFD simulations also provide guidance in designing physical experiments for those flow-control concepts, which appear promising

For FY01, CFD simulations were used to assist the development and the design of flow-control device to enhance the efficiency of compressors by reducing tip loss. The current project is a continuation on the research started under FY00 in which the Glenn-HT code was used to guide the design of wall-jet injectors for compressor stability enhancement. The wall-jet injectors will be demonstrated on axial and centrifugal compressor stages at GRC in 2001.

The current tip flow-control device is a recirculating casing treatment to be tested on NASA rotor 67. The device consists of intake, return, and injecting channels. The tested designs can be divided into 2 groups; ones with a plenum cavity and ones using guided channels through out. An example of plenum cavity is shown in Figure 1.

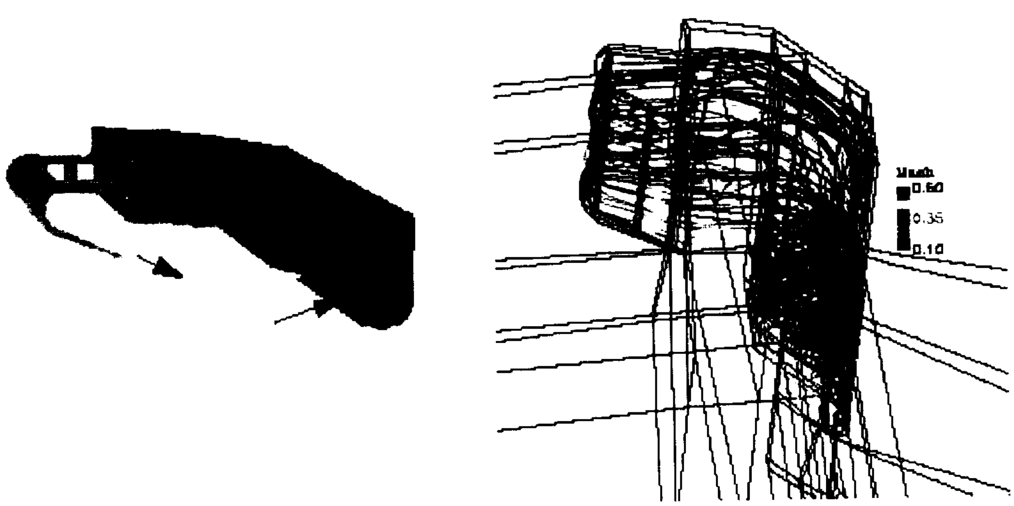


Figure 1 Plenum Cavity Casing Treatment

An example of guided channels is shown in Figure 2. In this geometry, inside each individual casing treatment, a group of 5 channels are encased within.

Figure 2 Guided Return Channels

Due to the large swirling flow field, extreme flow turning is needed to guide the flow from the intake to the correct injection angle. For geometries presented in Figures 1 and 2, both had excess loss caused by vortices induced by a combination of the swirling flow and sharp angles. Two alternative designs were introduced, they are similar in concept as the guided return channels but use circular tubes for easier flow turning. The eventual geometry will group a series of these tubes into one casing treatment unit. Of the two circular tube designs, Figure 3 shows the more promising geometry with the lowest total pressure loss of all the units tested.

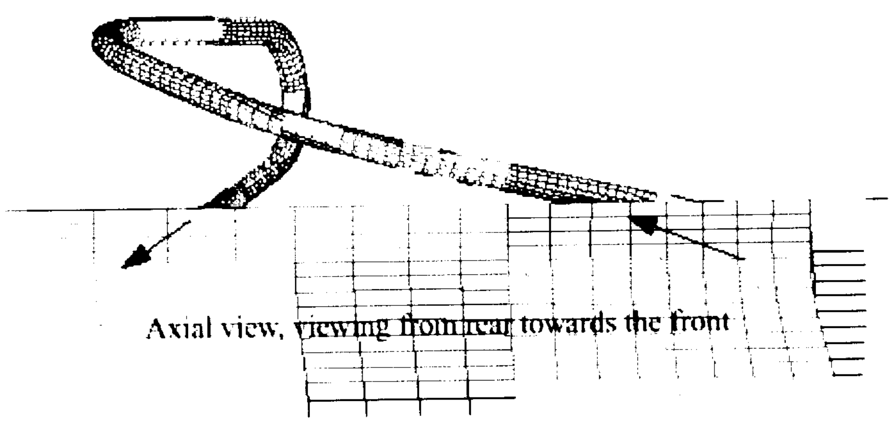
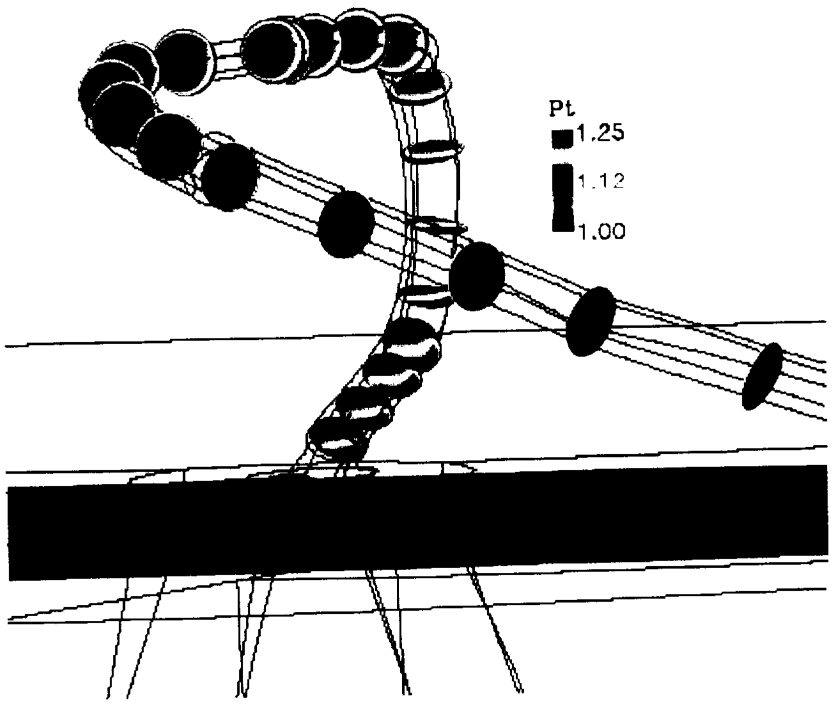


Figure 3. Circular Tube Casing Treatment.

Figure 4 shows the total pressure and Mach number distribution for the circular tube casing treatment.



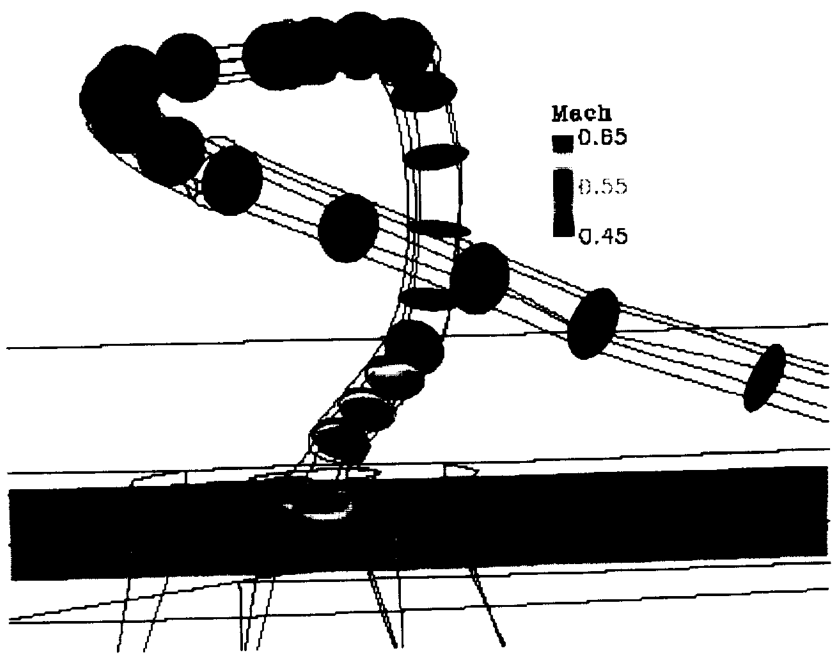


Figure 4. Total Pressure P_t and Mach Number Distribution.

From the current study, a tip flow control device based on the geometry shown in Figure 3 has been recommended and is expected to be built and tested in the FY02.